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MINERAL CONTENTS AND PLANT DIVERSITY IN CHALK GRASSLAND UNDER DIFFERENT MANAGEMENT: A CASE STUDY IN NORMANDY, FRANCE¹

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ABSTRACT

In order to assess the effects of sheep grazing on mineral contents and plant diversity in chalk grasslands, the dominant plant species of two contrasted plots (grazed, ungrazed) were monitored by permanent quadrats and sampled for mineral analysis. The results show a deficiency in trace elements from the grazed species and a mineral reservation in ungrazed species. Consequently, management conservation plans have to pay special attention to this unavailable resource by using intermittent grazing with unimproved animals.

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INTRODUCTION

In western Europe, calcareous grasslands are considered the result of neolithic human forest clearance. They have been used as sheep-walks and cultivated land for many centuries (Smith 1980). Nowadays, since the modern agricultural revolution (1950), these grasslands have lost their former significance as a food resource for agriculture and were progressively abandoned by domestic livestock. As a consequence, natural seral changes occurred in the absence of grazing, leading to natural succession which proceeded to plagioclimax of scrub and/or species poor-coarse grasslands (Willems 1990). The need of management to conserve these species-rich community by grazing sheep and cattle has been discussed in general terms by Wells (1965) and is now applied experimentally in northern Europe (Maubert & Dutoit 1995). Although the changes in floristic richness and diversity which occur in grazed or mown grassland are well known (Wells 1969), there are surprisingly few quantitative data available on mineral contents of chalk grassland turf and plant (Milton & Davies 1947, Smith et al. 1971). Nevertheless, effects of grazing on vegetation diversity strongly depend on both the intensity of grazing and the palatability of the dominant plants. In consequence, we clearly need to expand our information on the effects of the management regimes on such variables as plant mineral contents and on the ability of chalk grasslands to provide sufficient nutrients to support grazing animals.

STUDY SITE

The study was carried out on semi-natural chalk grasslands located in Saint-Adrien nature reserve 15 km south of Rouen (1°5'3"E, 49°19'22"N). The reserve is in the Seine valley which is situated in Normandy in northern France. The vegetation in the reserve consists of a mixture of different age stands of chalk grassland succession on Cretaceous chalk. Two plots were chosen for further investigations on mineral contents of chalk grassland species. The first plot corresponds to a fenced area of 0.7 ha, which is continuously grazed since 1984 with a mean stocking rate of 4 texel sheep.ha⁻¹.year⁻¹. The vegetation of the grassland corresponds to a mesotrophic calcicolous grassland with *Medicago lupulina* and *Trisetum flavescens*. The second plot corresponds to a tall grassland abandoned since 1950 and dominated by tussock grasses, e.g. *Brachypodium pinnatum* and *Sesleria albicans* with encroachment by some scrub species, e.g. *Acer pseudoplatanus* [code leaves L, code barks A], *Betula pubescens* [2,B], *Clematis vitalba* [3,C], *Cornus sanguinea* [4,D], *Corylus*

avellana [5,E], *Crataegus monogyna* [6,F], *Fraxinus excelsior* [7,G], *Ligustrum vulgare* [8,H], *Prunus spinosa* [9,I], *Rosa canina* [10,J] and *Viburnum lantana* [11,K].

MATERIALS AND METHODS

A point quadrat method was used to investigate the vegetation in the two plots (Stampfli, 1991). For each plot (grazed, ungrazed), two permanent 1 m² quadrats were marked for observations in homogeneous areas. For each of the four quadrats, point frequency records of 100 regularly spaced points (2 cm), consisting of 2 rows at regular distance of 33 cm were made with a needle. These quadrats were used to assess the Specific Contribution (SC%) of dominant plant species, plant richness and diversity. The SC% is the ratio between the frequency of a species to the total frequencies of all the species recorded.

Each month during the growing season (from May to September 1992), a handful of the dominant species and one 1 m x 1 m quadrat were randomly harvested in the two plots. The vegetation and individual plants were clipped at 2 cm from ground level and dried at 70°C for 24 hours. A soil sample was also taken in the two plots. Leaves and barks of scrubs were respectively sampled in August 1992 and in January 1993 because these periods correspond to the maximum of sheep consumption (Hillegers 1993). Plant and soil analysis were realised in the laboratory of Grassland Ecology (University of Louvain, Belgium). Chemical analysis of plants were performed on dry samples. Total mineral contents (CT) was obtained by calcination (450°C) and nitric acid digest. After filtration, insoluble ash (CI) are quantified. Soluble ash (CS) were measured by atomic absorption spectrophotometry for K, Na, Mg, Ca, Fe, Cu, Zn, and Mn. P was obtained by the same digestion and colorimetric determination using ammonium metavanate (Lambert 1992). The pH of soil in a slurry with water was determined using a glass electrode. The nitrogen and carbon were analysed using respectively Kjeldahl and Anne methods. Analysis of major (K, P, Na, Mg, Ca) and trace elements (Fe, Cu, Zn, Mn) were realised by atomic absorption spectrophotometry after extraction with ammonium acetate and EDTA (pH= 4,65).

RESULTS

There is no significant difference between chemical soil composition of the two plots. The chemical analysis show low levels of Fe and Cu in relation with the weakness of the chalk for these ele-

ments. Likewise, turf analysis show that mineral contents of the two plots are particularly low notably for Cu, Zn and Mn which are under the threshold of animal deficiency. Plant mineral analysis show some differences in the distribution of each element between dominant species. Multivariate analysis on the mean concentration matrix shows the mineral that influence variation in the dominant plants analysed in the two plots.

The first three axes account for almost 70% of total variation contribution with 37,9% for axis 1 and 19,3 % for axis 2. The first axis is strongly influenced by trace elements Fe, Cu, Zn and Mn. Species with a high content of trace elements correspond to the ungrazed species of plot 1 e.g. *Ranunculus bulbosus*, *Thymus praecox*, *Veronica teucrium*. Axis 2 is more correlated with Ca, CT and Mg. Species with high content of these elements correspond to Fabacea e.g. *Ononis spinosa*, *Anthyllis vulneraria* and ungrazed species present in the two plots e.g. *Origanum vulgare*, *Leontodon hispidus*, *Seseli libanotis*. Some species, which are eliminated by trampling in plot 1, are also rich on these elements and correlated with axis 2 (e.g. *Centaurea scabiosa*, *Teucrium scorodonia*). At the opposite of the two axes appear graminoids which are especially low for all the mineral except CI (e.g. *B. pinnatum*, *Festuca lemarii*, *S. albicans*, *Carex flacca*). These species correspond to the most grazed plants in plot 1. Projection of scrubs data as supplementary individuals (i.e. mineral contents of leaves and barks) shows that barks have low amount for the majority of minerals except CI (Ca in the case of *C. monogyna*). Only leaves of *A. pseudoplatanus* are particularly correlated with axis 1 compared with the leaves and barks of the other scrub species.

PCA carried out on mineral contents of leaves and barks for scrubs shows that the first axis (32,1%) is strongly correlated with CT, P, CI, Mg and K. Leaves are positively correlated with this axis except those of *B. pubescens* and *C. avellana*. At the opposite, barks are negatively correlated with this axis (except *A. pseudoplatanus*) as are mineral contents on Na and Zn. As for Axis 2 (18,9%), it is strongly correlated with Ca. Grazed leaves and barks, particularly rich on Ca, CT and CI, are positively correlated with this axis (e.g. *C. sanguinea*, *C. monogyna*, *C. vitalba*, *F. excelsior*). In the opposite, ungrazed barks (e.g. *B. pubescens*, *C. vitalba*, *L. vulgare*, *R. canina*) and +/- grazed leaves (e.g. *V. laniana*, *L. vulgare*, *R. canina*, *P. spinosa*) are negatively correlated with axis 2.

DISCUSSION

The weakly yield of most chalk grassland turf and unpalatability of their dominant species is a well-known phenomena (Williamson 1976, Hillegers 1993). As regard to our results and threshold of animal deficiency currently admitted by agronomists (Jarrige 1988), mineral contents of chalk grassland turf and plants are also particularly low notably on trace elements.

This could be linked with the scarcity and the unavailability of these elements in the chalk and shallow rendzina (Dutil 1972).

Sheep grazing have a good incidence for plant diversity and subsequently mineral diversity. For example, *B. pinnatum* which is dominant in the abandoned plot, is also one of the more poor species. If grazing leads to a higher diversity in the plant community (Alard et al. 1994), it allows also the occurrence of new species which represent new mineral sources. This can be of interest provided that they are eaten by animals. Nevertheless, several years of heavy grazing with improved sheep (Texel) have been necessary to broke the mat of dead material and reduce the coarse grasses (*B. pinnatum*, *S. albicans*). Then, there is a risk of mineral deficiency for these animals, which stay a long time in the same plot of unimproved chalk grassland, and eat preferably poor mineral species like Poaceae (Lamand 1987). Denudt & Lambert (1976) have shown that the

maintenance of plant diversity in extensive hydrophilous meadow is favourable to the mineral balance of animals. Nevertheless, live-stock must be able to eat mineral-rich species plants which are usually refused by improved animals. Therefore, the solution to restore species-rich chalk grasslands could be the realisation of an intermittent grazing system with unimproved animals, where periods of grazing and stocking-rate are in agreement with plant diversity and animal health (Wells 1980).

The long term solution for biological conservation of chalk grassland must involve grazing, but the management system to be employed will differ depending on, the objectives of conservation (animal or plant diversity, scrub or coarse grass decrease), the statute of the land (farmland, nature reserve, amenity area etc.), and the type of animals involved. If very good results have been achieved on England nature reserves by heavily grazing temporary paddocks of electrified "flexi-netting", the use of an unimproved sheep livestock conducted by a shepherd could also show very good result without problems of unpalatable species and mineral deficiencies.

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